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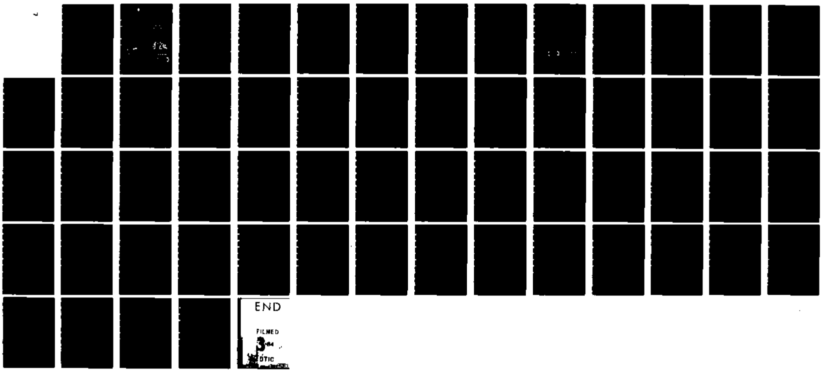

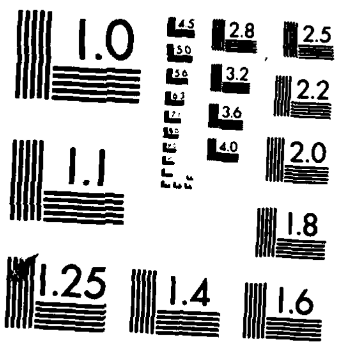

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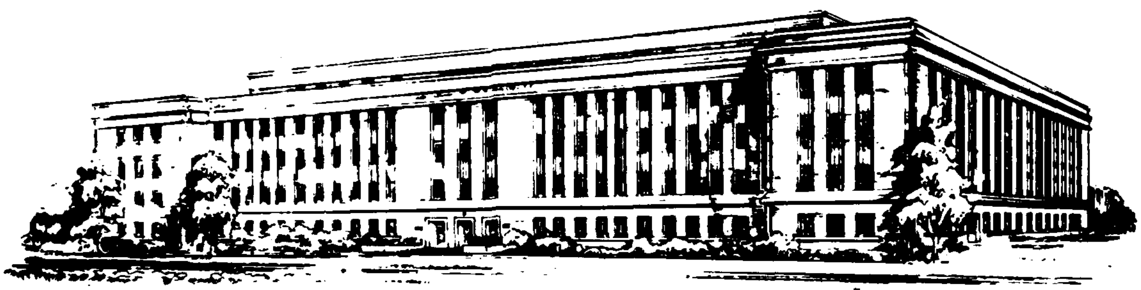
MOBILIZATION AND DEFENSE MANAGEMENT TECHNICAL REPORTS SERIES

U.S. DEPENDENCY ON FOREIGN SOURCES FOR COMPONENTS: THE CASE OF SEMICONDUCTORS



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This paper investigates the foreign dependency on semiconductor products and the potential impact it may have on military mobilization.

7. DAVID J. RICHARDS, COL, USA; RICHARD T. SALE, III, GM-15, D/A; CLARENCE R. WILLIAMS, COL, USAF; JO ANN WILLIAMS, GM-15, DOE

THE INDUSTRIAL COLLEGE OF THE ARMED FORCES
NATIONAL DEFENSE UNIVERSITY

MOBILIZATION STUDIES PROGRAM REPORT

~~UNITED STATES~~ DEPENDENCY ON FOREIGN SOURCES FOR ~~CRITICAL ELECTRONICS~~ COMPONENTS: THE CASE OF SEMICONDUCTORS

by

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A RESEARCH REPORT SUBMITTED TO THE FACULTY
IN
FULLFILLMENT OF THE RESEARCH
REQUIREMENT

RESEARCH SUPERVISOR: DR. JOHN E. STARRON, JR.

THE INDUSTRIAL COLLEGE OF THE ARMED FORCES

MARCH 1983

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ABSTRACT OF STUDENT RESEARCH REPORT
INDUSTRIAL COLLEGE OF THE ARMED FORCES

NAME OF RESEARCHER (S)	TITLE OF REPORT
See title page.	Foreign Dependency on Critical Electronics Components: The Case of Semiconductors.
SECURITY CLASSIFICATION OF REPORT	**REPORT NUMBER**
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ABSTRACT

Problem Statement: This paper investigates the foreign dependency on semiconductor products and the potential impact it may have on military mobilization.

Findings/Conclusions: A study of the issue of foreign dependency on semiconductors reveals:

1. The U.S. semiconductor industry is threatened by competition from abroad. Some of this competition is subsidized by foreign governments.

2. There is an overwhelming dependence within the United States for semiconductors processed, in some manner, offshore.

3. There is great potential for military systems to contain large amounts of semiconductors processed offshore.

4. The military has no established system to track geographical origin of most of its semiconductors.

5. There may be a problem with regard to mobilization caused by off-shore assembly of semiconductors but DOD does not presently have the data necessary to make a definite judgement.

Recommendations:

1. DOD should initiate and support efforts undertaken to strengthen the U.S. semiconductor industry.

2. DOD should establish a system for highlighting foreign dependence vulnerability data and that information should be taken into account within the industrial preparedness planning process.

3. The DOD needs to determine in the abstract whether foreign dependency poses a threat to national security or whether or not geographically dispersed sources satisfy national interest.

4. The DOD should establish requirements for identifying foreign dependencies associated with semiconductors in the development and procurement of new systems.

THIS ABSTRACT IS UNCLASSIFIED

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EXECUTIVE SUMMARY

This study was undertaken to investigate the foreign dependency of the military resulting from the use of semiconductors which are manufactured totally or in part off-shore and to determine, if possible, its impact on military mobilization. Semiconductors are critical components in most of today's military hardware. A foreign dependency poses potential problems in meeting the expanded production of that hardware should the United States have to mobilize for war.

Semiconductors were invented in the United States and virtually all major advances in the rapidly changing technology originated here. This greatly contributed to the dominance by American firms of the semiconductor market, currently 60 percent of sales worldwide.

Since the 1960's, the United States semiconductor industry moved labor intensive operations off-shore to take advantage of the lower cost labor. Although design and fabrication is primarily done in the United States, most, if not all, U.S. firms have assembly plants located off-shore. Semiconductors marketed domestically have been for the most part re-exported to the United States after assembly.

Japan has targeted the semiconductor industry to achieve domination of the world market. Their government has assisted Japanese firms in this effort through direct funding and shared technology. Additionally, they have effectively closed their market to competing U.S. semiconductor firms. Through aggressive pricing policies, the Japanese have attacked the mass memory market causing recent losses to once profitable U.S. firms of over $140 million. The success of the Japanese in these efforts have placed the United States semiconductor industry in jeopardy.

The military provided the major market for semiconductors during the early 1950's and was instrumental in providing the necessary capital for early research and development efforts. Today, although semiconductors are found in most military hardware, military procurements represent only seven percent of the total market. And for the most part, the semiconductors used by the military represent dated technology. Although the military market is limited, it is critical and is expected to grow 15 percent annually for the next five years.

The foreign dependency issue relative to semiconductors has been raised by many studies and reports over the past five years. Most studies have recognized that approximately 90 percent of the semiconductors industry's assembly capacity is located off-shore. From this fact, it has been inferred that the military's dependency on foreign assembled semiconductors is very high. A Defense Science Board study done in 1980 estimated 80 to 90 percent of the semiconductors used by the military were assembled and tested outside the United States.

The industrial preparedness program was established to insure an adequate industrial base for mobilization. However, the program as structured and implemented, is inadequate in dealing with the foreign dependency issue. It has not provided the information necessary to determine the extent of the foreign dependency problem with semiconductors or the information necessary to determine if the domestic semiconductor manufacturing capacity is satisfactory to meet mobilization requirements.

There is, in fact, no system within DOD that permits the origin of semiconductor manufacture to be determined with certainty. As a result, the extent of the military's semiconductor foreign dependency is unknown. Information gathered as a result of this study confirmed that most semiconductors used by the military have a high potential for being manufactured off-shore.

Three recommendations are made in the study. First, as a result of Japanese targeting efforts and the threat they pose to the United States semiconductor industry, the DOD needs to initiate and support efforts to strengthen the U.S. capabilities to respond to the Japanese challenge. Second, there needs to be a determination made as to whether foreign dependency on sources for specific semiconductors poses a threat to national security. It is not clear that diversified off-shore assembly operations are a liability to U.S. security interests. Third, if it is determined that foreign dependency in general is a threat to national security, then an information system needs to be developed to determine the extent and nature of that dependence so that appropriate action can be taken.

CHAPTER I

THE SEMICONDUCTOR INDUSTRY

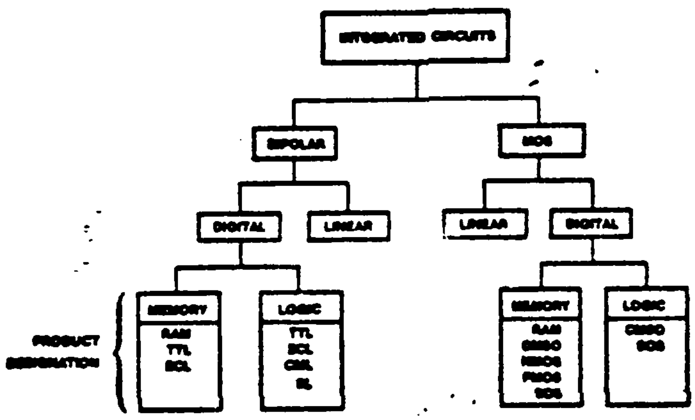
Semiconductor Technology Overview

The semiconductor industry is a foundation upon which virtually every technical advancement in today's modern world is built. The first semiconductor device, the transistor, was invented in 1947, and since that time this industry has had a profound impact throughout society. In 1980, the chairman of the board of Advanced Micro Devices coined a now famous metaphor: "Semiconductors are the crude oil of the 80's."[1] Considering the pervasive impact of semiconductors and microelectronics, the remark is particularly appropos.

Semiconductor technology can be divided into two broad categories: (1) discrete devices and (2) integrated circuits (IC's). A discrete device, such as a resistor, transistor, or diode, is an electrical component which performs a single independent function. An IC is an array of devices which is integrated on and in a crystal of semiconductor material, usually silicon, and which performs an electronic circuit function. The interconnected elements of the IC are inseparably formed and mounted inside of a special protective package. The IC, or "chip." package typically has pins along its sides which allow the package to be plugged into a socket or soldered to a printed circuit board. Figure 1 is a family tree of the IC, showing names and some key relationships of IC technology and the abbreviations of several of the more important digital IC devices.

FIGURE A

INTEGRATED CIRCUIT RELATIONSHIPS[2]



An additional important distinction which is applied to IC technology is the degree of circuit complexity and number of components per chip. The technology can be classified as small-, medium-, large-, or very large-scale integration. Currently, large-scale integration with 1,000-10,000 components per chip, and very large-scale integration (VLSI) with more than 10,000 components per chip, dominate. VLSI devices accounted for 22 percent of the U.S. IC market in 1981, and they are projected to account for 90 percent of the market by the end of this decade.[3] By that time, VLSI chips will contain serveral million components per chip.

The discrete device market is relatively mature. It represented $3.1 billion in 1981. It has remained during the last five years at a level of about one-third the total value of the semiconductor market.[4] Discrete devices do not experience the extremely rapid growth or technological innovation characteristic of the remainder of the semiconductor market. Integrated circuits in general, and digital IC's in particular, have been the area of semiconductor technology which have the greatest recent growth and which will continue to dominate the market through the 1990's.

Characteristics of United States Semiconductor Industry

During the short history of the semiconductor industry, a number of factors have emerged as characteristic of the industry. Certainly the Silicon Valley story attests to the important roles of innovation, enterprise and venture capital. Both discrete semiconductors and IC's were invented in the United States, and virtually all major innovations in semiconductors have

originated here. American firms have dominated worldwide sales and continue to hold more than 60 percent of the world market share. This world dominance by U.S. technology occurred while domestic companies fiercely competed among themselves, on the basis of both cost and design.[5] During its lifetime, the industry has grown at approximately 20 percent per annum. Table 1 provides data on the semiconductor market during the 1980-84 period. The impact of the recession in 1981-82 is apparent--even in this rapidly growing segment of the economy.

Two distinct industry types have developed. Merchant firms are those operating in the open market. Captive producers are those semiconductor divisions of larger integrated companies which produce chips for their own internal use. In 1981, approximately 33 percent of U.S. chip production was by captive producers, and this is expected to rise to 40 percent by 1985.[7]

Perhaps the most significant characteristic of the semiconductor industry has been its phenomenal and sustained pace of technological change. Each innovation of the industry has been quickly followed by new developments which provide better performance at lower cost. As each cost threshold is crossed, previously uneconomic applications become feasible. The rapid technological pace has meant that every year for the past two decades, the number of components on a chip have approximately doubled.[8] The price, therefore, per bit of information or per function has fallen rapidly. This strongly disinflationary pricing mechanism necessitates that the industry attempt to realize its profit through economies of scale and high volume sales of each IC.

TABLE 1

SEMICONDUCTOR PRODUCT SUMMARY[6]

Product	Annual Sales (Millions)				
	1980/Change	1981/Change	1982/Change	1983/Change	1984/Chang
Digital Bipolar	$2084 +46.8%	$1907 - 8.5%	$1998 + 5%	$2414 +21%	$ 2925 +21%
Digital MOS Memory	1832 +40.3%	1533 -16.3%	1680 +10%	2158 +28%	2805 +30%
Digital MOS Logic	1720 +37.5%	1678 - 2.4%	1892 +13%	2390 +26%	3063 +28%
Analog	1436 +17.8%	1458 + 1.5%	1607 +10%	1938 +21%	2300 +19%
Total Integrated Circuits	7073 +36.1%	6576 - 7.0%	7177 + 9%	8900 +24%	11,093 +25
Total Discrete	2952 + 5.9%	2699 - 8.6%	2817 + 4%	3037 + 8%	3270 + 8

Source: Semiconductor Industry Association, Semiconductor Forecast 1982-1984, April 198

The rapid rate of technological change also means that semiconductor processing plant and equipment become obsolete quickly, often in two to three years. Additionally, as the complexity of IC's increases, the cost of each new generation of processing equipment jumps dramatically. A Western Electronic Manufacturers Association Study in 1979 indicated that the semiconductor industry was the most capital-intensive segment of the electronics industry.[9]

The industry is also highly research and development (R&D) intensive. The need to constantly improve and replace products with more sophisticated ones requires a large and highly skilled R&D workforce of engineers and a substantial investment. Leading semiconductor companies are investing up to 12 percent of annual sales in R&D.[10]

In the early 1960's, the military provided a major market for the semiconductor industry. However, the explosive growth of the commercial market has far overtaken military demand. Military semiconductor sales were 7 percent of the industry output in 1981.[11] Due to this low volume, the competition with commercial business and the tendency for military requirements to lag state-of-the-art technology, many semiconductor firms do not seek extensive involvement in specialized military procurements. The military position in the marketplace should be enhanced in the 1985 time frame when the impact of the DOD sponsored Very High Speed Integrated Circuit (VHSIC) R&D program is felt.

Offshore United States Semiconductor Operations

Since the early 1960's there has been a clear trend for the U.S.

semiconductor industry to utilize offshore production facilities. Beginning with production of discrete devices and rapidly accelerating as digital IC production increased, U.S. industry moved the labor intensive portion of the manufacturing process outside the country.[12] This action occurred primarily because American companies recognized an erosion of their comparative advantage due to increasing Japanese semiconductor manufacturing, which utilized far cheaper labor.

Wafer design and manufacture, which required highly skilled manpower and extensive investment in R&D and capital equipment, were retained in the U.S. Labor intensive assembly (wire bonding) operations, which in the early 60's were primarily manual tasks, were moved to densely populated countries such as Hong Kong, Taiwan, South Korea and Mexico. The work force in these areas was unskilled, but trainable, and labor costs were 1/10 to 1/20 of those in the United States. The less developed countries welcomed the employment created by the new investments, which were typically wholly owned U.S. subsidiaries. Virtually all of the assembled IC's were re-exported to the United States where they were tested and marketed domestically.

The 1970's saw a dramatic increase in the world demand for semiconductors. Offshore assembly operations had proven to be extremely successful and provided a means for the United States to remain internationally competitive and to keep pace with IC demand. Singapore joined Hong Kong, South Korea, Taiwan, and Mexico as first tier, primary assembly locations. Professional manpower pools, varying from technicians to engineers, developed in these locations. They became increasingly able to support high volume assembly

operations, including some semi-automated processes and limited final IC testing. As these countries advanced, they became motivated primarily by the transfer of technical skills so that local high technology industry could be developed. A new group of countries (Brazil, Indonesia, Israel, Malaysia, Thailand, the Philippines) emerged to fill the gap as the first tier group moved up the technological ladder. During this rapid growth period, the offshore assembly facilities continued as wholly owned subsidiaries of the United States parent companies.

The most probable scenario for the 80's is continued technological progress by the first tier countries as Hong Kong and Korea move into the computer and telecommunications markets and as Brazil and Israel rapidly develop. Significant changes will occur as local host nation equity replaces U.S. subsidiary ownership, and as the former first tier countries gain direct access to world markets. These countries will themselves extensively utilize offshore operations in the newer technologically underdeveloped countries, such as Sri Lanka, Portugal, and Spain. In the late 80's and in the 90's the leaders of the first tier countries will continue to develop their expertise and will utilize state-of-the-art equipment and processes to compete with the United States and Japan in regional and world markets.

Leaders in the industry have cited several benefits of this development of the Third World/Lesser Developed Country semiconductor industry.[13] Aside from the obvious social and economic benefits to the concerned nation, there are political benefits to the U.S. as ties to those countries are strengthened. From an industry point of view, the transfer of labor intensive

processes offshore at a lower capital outlay permits the United States producer to increase trade volume through increased cost competitiveness. Additionally, United States operations can concentrate on research-intensiv activities, increasing both the quality and quantity of the U.S. labor forc Most significantly in the industry's long term view, is the vast Third World market created for U.S. exports.

In the near term, it appears that a high percentage of package assembly, screening, and electrical testing will remain offshore. In addition to production cost advantages of offshore production, U.S. tariff regulations (items 806.30 and 807.00) afford favorable duty rates to offshore, value-added, assembly, and testing. While some industry analysts believe that the increasing automation of process technology will result in a trend toward increased onshore assembly, this is not yet clear. The Semiconductor Industry Association (SIA) reports that the industry seeks to increase reliability and yield by remaining offshore and utilizing the manpower cadre and technological infrastructure which has been developed.[14]

This desire for full and open development of world wide markets, in spite of technology transfer and foreign competition questions, is consistent with the position taken by the SIA in seeking free access to Japanese markets and assistance in combatting subsidized targeting by Japan.[15]

<u>Comparative Industrial Policies</u>

Today, the U.S. semiconductor industry faces a serious challenge. The question of whether our domestic industry can compete with Japan's and, in fact, survive is increasingly cast in terms of comparisons between two widely

differing industrial systems. The Japanese, as inhabitants of a densely populated island with scarce natural resources, have traditionally felt compelled to excel as a trading nation. After World War II, protection of Japanese industry was sanctioned by laws designed to foster reconstruction of the Japanese economy. In the postwar period a national strategy for success in world trade was forged through a partnership of government, industry, and labor. The strategy prescribed targeting of promising products for world markets and the production of high-quality goods at economic costs by Japan's well educated, skilled, and disciplined work force.[16]

By the early 1970's, the Japanese had attained many of their economic goals, but were encountering serious environmental damage from heavy manufacturing activities. Recognizing the promising future of information technology, the Japanese refocused their policy to emphasize "knowledge-intensive" industry. In line with this policy decision, semiconductor and computer industries were singled out for special treatment by the government.[17]

The success of the Japanese in their efforts has been confirmed by the SIA in a study just completed. The SIA study found that between 1976 and 1982, the Japanese government provided at least $500 million to major Japanese semiconductor firms. An additional $1.5 billion has been channeled to these same firms for objectives in closely related sectors (e.g. computers which involve semiconductor support). In fact, these figures, the study explains grossly underestimate the value of the government's assistance. One Japanese executive estimated that without government assistance including tax

TABLE 2

SALES OF JAPANESE SEMICONDUCTOR COMPANIES

Company	1979 Net Sales ($ in millions)[a]	Semiconductor Sales to Total Sales (percent)[b]
Fujitsu, Ltd.	$ 1,838	6.7
Hitachi, Ltd.	10,725	4.1
Matsushita Electric Indus. Co., Ltd.	9,846	2.3
Mitsubishi Electric Corporation	3,896	3.8
Nippon Electric Company Ltd.	3,292	17.8
Toshiba Corporation	7,096	5.5
Mean	6,115	6.7

Notes: [a]Converted at 240 yen per $1.00, the approximate rate of exchange on December 31, 1979.

[b]Based on 1978 sales.

Source: Dataquest Incorporated.

advantages, use of government facilities, and free access to government R&D, Japanese firms would have spent five times what they actually spent to acquire advanced semiconductor technologies.[18]

Direct government involvement is only one element of Japanese challenge. Many experts believe that the most serious aspect of the commercial competition from Japanese companies arises from structural differences within the economic environments in the U.S. and Japan.

In Japan, semiconductor production typically is conducted by divisions of large electrical manufacturing companies, e.g., Hitachi and NEC. These units produce for internal company consumption and market sales. As indicated in the table below, sales of companies which accounted for approximately 78 percent of total Japanese semiconductor sales in 1978 averaged slightly over $6 billion in 1979. The diversity of their operations is indicated by the fact that only seven percent of these companies' combined revenues were derived from semiconductor sales.

In contrast, the U.S. independent semiconductor manufacturers like Texas Instruments, National Semiconductor, and Intel preempted the market from major electrical manufactures like General Electric and Westinghouse, and concentrated on selling components to manufacturers of end products. Of the nine U.S. companies which accounted for approximately 60 percent of total semiconductor sales by U.S. companies, only two had sales in excess of $1 billion. Sales of the typical U.S. semiconductor company (excluding Motorola and Texas Instruments) averaged only $400 million as depicted in the following table.

TABLE 3

SALES OF U.S. SEMICONDUCTOR COMPANIES

1979

Company	Net Sales ($ in millions)	Semiconductor Sales to Total Sales (percent)[a]
Advance Micro Devices, Inc.	$ 148	89
American Micro Systems, Inc.	109	89
Fairchild Camera & Instrument Corp.[b]	625[d]	69
Intel Corporation	663	75
Intersil, Inc.	139	69
Mostek Corp.[c]	200[d]	93
Motorola Inc.	2,714	31
National Semiconductor Corporation	720	85
Texas Instruments Inc.	3,224	36
Mean	949	71

Notes: [a]Based on 1978 sales.

[b]Acquired by Schlumberger Ltd. in October, 1979.

[c]93% of shares acquired by United Technologies Corp. in November, 1979.

[d]Estimate.

Source: Dataquest Incorporated.

Since the size of a company is often an indicator of a proven track record, management depth, breadth of product lines, market share, and position within its industry, larger companies usually command a higher credit rating than smaller companies with the same degree of leverage. Consequently, the relatively small size of most of the U.S. semiconductor companies places them at a disadvantage in raising capital at attractive rates.[19]

Differences in capital formation practices also appeared to favor Japanese in this capital-intensive industry. World demand for semiconductors has grown at an average rate of 25 percent a year. To maintain their market share companies must expand at that rate and the rising cost of fabrication plants intensifies the requirement for investment funds.

In Japan, government funding provides a signal to the Japanese banks as to which industries are favored and thus are the best prospects for loans. Japanese companies pay interest rates that are low compared with those paid by their U.S. counterparts. Japanese semiconductor companies also employ significantly higher debt leverage than U.S. companies. Many Japanese companies maintain debt-to-capital ratios as high as 60 to 70 percent. By comparison, U.S. companies are fairly conservatively leveraged. During the past three years, the median debt-to-capital ratios in nine U.S. companies was between 16 and 18 percent.[20] Consequently, Japanese firms are better able to manage expansion. American companies typically finance expansion out of earnings and the issue of stock. The portion of investment capital borrowed from banks is less important. The venture capital market that fueled expansion in the early period of the semiconductor industry boom has until

recently been supine while recession and high interest rates have limited other sources of investment funds.[21]

Japanese market strategy has also worked to their advantage in electronics. American companies which traditionally dependent on stock issue for capital have been concerned with short term profits, in part because management is answerable to stockholders who are concerned with profitablity. Japanese companies, because they are export oriented put greater emphasis on expanding their market share rather than on making immediate profits.[22] Japanese managers also seem to have greater flexibility in using resources for research and development and for personnel training, as well as for plant investment.

Impact of Japanese Policies

The targeting system has created a business environment for Japanese firms in which the risks of rapid, large scale investments in capacity expansion, and aggressive pricing to increase market share are outweighed by the risk of failing to take such steps and thus losing favored status in Japan. Japanese firms race to build capacity and market share in a competion that has a substantial adverse impact on American firms.[23]

A graphic demonstration of the effects of Japanese targeting is the 64K Random Access Memory (RAM) experience in 1980-1982. Charts A through D, Figure B summarize the sequence of events. Support by their Government enabled six Japanese firms to go into volume production of 64K RAMs by early 1981, ahead of all but two U.S. firms. (A critical factor that allowed so

FIGURE B

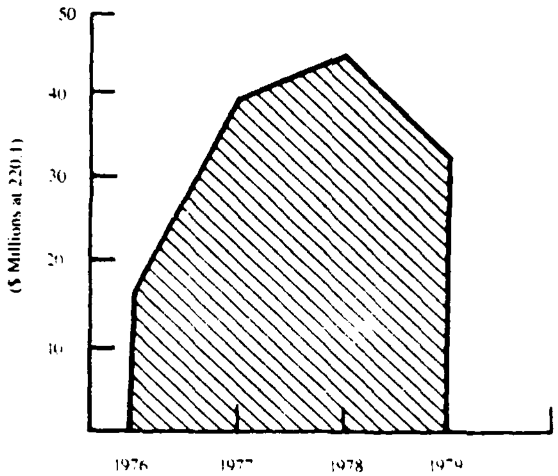
SEQUENCE OF EVENTS SUMMARY

Chart A

~~Chart II~~

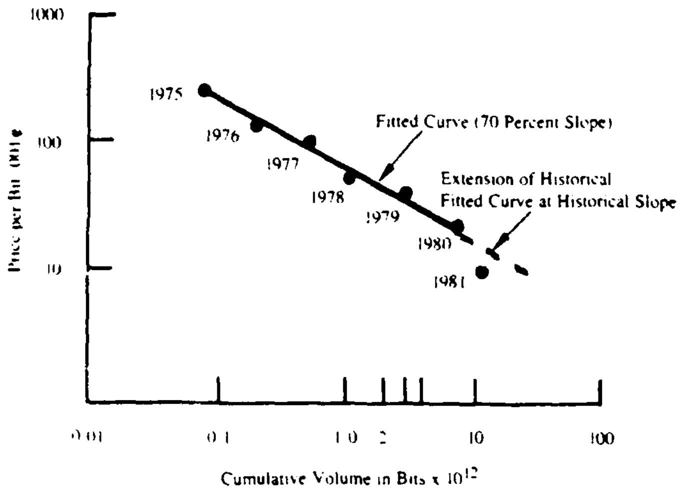
The 64K RAM Experience

Japanese Government Financial Aid to the VLSI Project



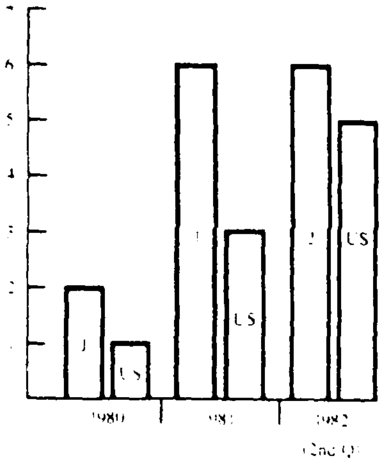
Coupled with other assistance, the VLSI Project enabled Japanese firms to enter the 64K RAM market *before* U.S. firms and to establish a dominant world market share.

CHART E

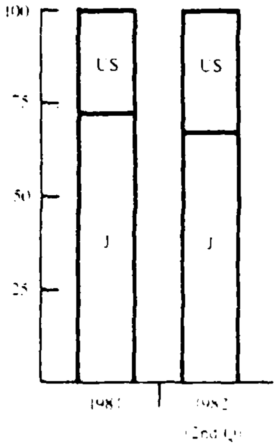


Led by Japanese pricing, all RAM prices fell sharply in 1981, in an unprecedented break with the historical pattern.

CHART B

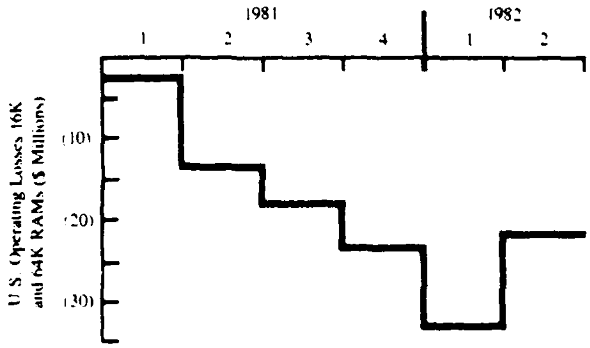


Number of Firms Attaining Volume Production (20,000 units per quarter)



World Market Share 64K RAMs

CHART D



U.S. firms experienced large losses on RAM sales.

many Japanese firms, including some who had never produced RAMs before, to get into production before American firms was a joint VLSI research cooperative that subsidized research and development and shared technology among all Japanese firms). U.S. firms had to develop their technology separately, and as of early 1981 only two had succeeded.[24]

Taking advantage of their head start and having a large number of competitors vying for a still small market, the Japanese began slashing 64K RAM prices drastically from $30 to $8 during 1981, or a decline of more than two-thirds. The net effect was a marked downward displacement of the historical pricing pattern.[25] Traditionally RAM prices have fallen 30 percent for each doubling of volume. In 1981 they dropped at 2 1/2 times that rate.

The effect of the Japanese export effort on U.S. producers has been serious. Seven of the twelve U.S. producers of 16K RAMs, the prior generation product, are not producing 64K RAMs. Those who did choose to stay in the RAM business have suffered over $140 million in losses in 1981 and 1982. The implications of U.S. disinvestment in dynamic RAMs are serious. RAMs have traditionally generated technological capability that has been translated into leadership in other semiconductor product areas.[26] Producers of RAMs must master techniques which once mastered can be applied to virtually all other semiconductor types. Moreover, the 64K RAM is forecast to become the highest volume product of the industry's history.

The 64K RAM experience repeats a pattern familiar to many other industries targeted by the Japanese and represents the "entering wedge" of an all-out

assault on other semiconductor markets. Continuing past special treatment, the Japanese government has budgeted nearly $300 million over the next decade for semiconductor related research projects and has developed very recently design and manufacturing techniques for the 256K RAM, (the 64K RAM successor), in government laboratories. There manufacturing techniques has been shared with Japanese companies at no cost.[27]

The magnitude of the challenge to the semiconductor industry is becoming exceedingly clear in recent trends in bilateral trade as shown in Figure 3).[28] The Japanese market is still effectively closed to foreign competition as indicated in Figures 4 and 5. Always a small percentage, U.S. sales in Japan are now declining and are actually lower now than at times in the past when officially protected. Additionally, U.S. firms within the last three years have repeatedly experienced a sudden drop in sales, and at the same time, a virtual total loss of market as soon as Japanese companies have been able to supply a particular part. Japanese exports have increased dramatically, and Japanese sales as a percentage of U.S. consumption have doubled. Moreover, U.S. imports of Japanese semiconductors are "hidden" --the devices are incorporated in imported Japanese consumer electronic and information industry products, and they do not show up in trade statistics. One U.S. semiconductor firm estimated the value of such hidden imports at $675 million in 1981. Evidence of the success of the Japanese national industrial policy is demonstrated by a positive trade balance with the United States in semiconductors sales and consumption.[29]

FIGURE C

RECENT TRENDS IN BILATERAL TRADE

Recent Trends in U.S.-Japan Semiconductor Trade

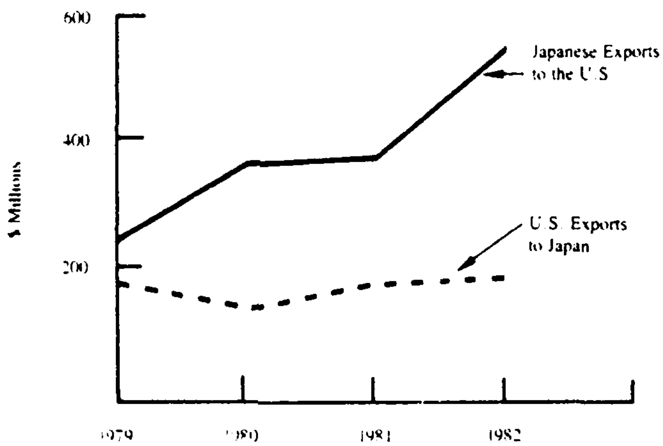
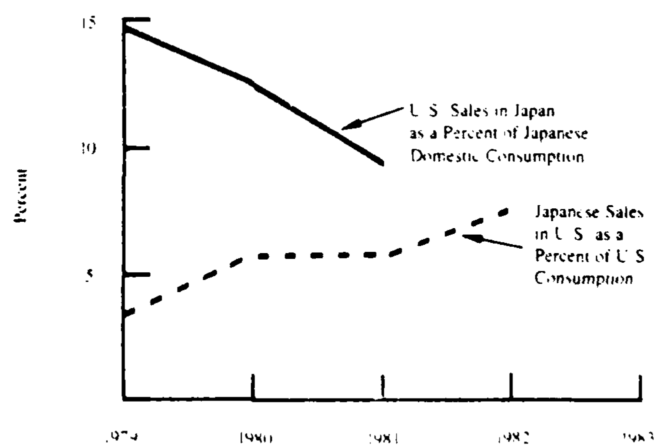


Figure 3

Import Sales as a Percent of Total Domestic Semiconductor Consumption



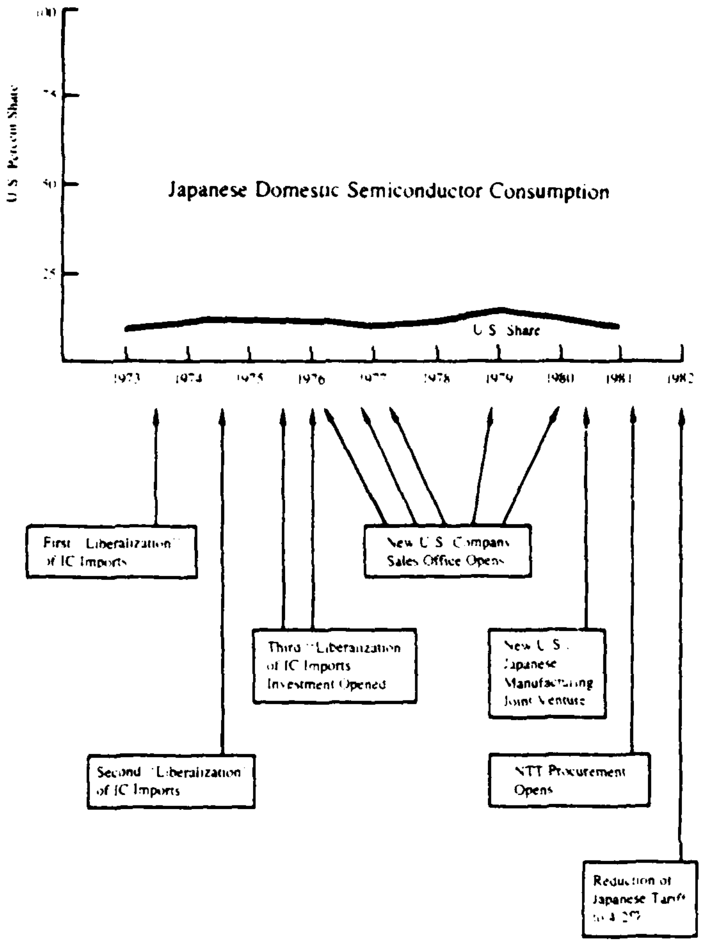
Sales include merchant only
Domestic consumption includes
merchant and captive.

FIGURE D

JAPAN'S MARKET REMAINS CLOSED

Japan's Market Remains Closed

U.S. share in 1981 is the same as its share in 1973, despite various "liberalization" measures and U.S. investment efforts.



FOOTNOTES

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CHAPTER II

FOREIGN DEPENDENCY ISSUE

Introduction

There are many people both within and outside of the Department of Defense (DOD) who believe that foreign dependency on semiconductors could seriously affect the mobilization posture of the United States in the event of war. If this foreign dependency does pose a threat to our military mobilization capability, then action must be taken to resolve the situation.

The foreign dependency issue relative to semiconductors has been raised in many studies and reports over the past five years. A 1977 Defense Electronics Supply Center (DESC) report stated that "it is difficult to estimate precisely how much integrated circuit assembly is done overseas, but it is thought to be about 90 percent." The report went on to note that the "strategic implications of these assembly sites are not favorable to DOD. In a major mobilization situation, the distances involved and the relative insecurity of the Far Eastern countries could lead to immediate and initial shortages of vital integrated circuit types."[1]

A 1980 Congressional report expressed similar concerns. The report found that the majority of United States manufactured semiconductor devices were assembled in Malaysia, Singapore, Taiwan, the Philippines, Korea, and Hong Kong.[2] In its conclusion on foreign dependency, the report stated, "the panel finds this dependence on off-shore labor for assembly of critical defense related components is as troublesome as our off-shore dependence for critical materials."[3]

The Defense Science Board in a report made in 1981 estimated that 80 to 90 percent of the semiconductors used by the military were assembled and tested outside the United States.[4] The report also stated that "most ceramic packages...are supplied from Japan..."[5] This is significant because ceramic packages are required for many military IC applications.

Because of the growing evidence of U.S. military foreign dependence on electronic components, including semiconductors, the Joint Logistics Commanders established an ad hoc group on reduction of foreign dependencies in June 1982 to study the issue. The group is charged with collecting and analyzing data and recommending solutions on foreign dependency for any component and manufacturing problems discovered.[6] A second effort directed by the Deputy Under Secretary of Defense for Research and Engineering is an ad hoc advisory group composed of government and industry experts which is tasked with reviewing problems in the supplier base for critical electronic components. Initial efforts of this latter group have been directed towards reexamining dependence on foreign suppliers, especially Japan.[7] Both of these efforts are recent initiatives for which results are not expected for sometime.

DOD Requirements for Semiconductors

National defense and the space programs provided the first market for semiconductors. The government supplied most of the capital to build the initial production capacity and in the early 1950s pumped over a billion dollars into research and development.[8] In these early years, the military

and space demand for these devices represented the dominant requirement. Although the use of semiconductors in complex military systems is still growing, the military's share of the semiconductor market has lessened considerably. Today military procurement of semiconductors is estimated to represent only seven percent of the total market.[9]

Although relatively small, the procurement of semiconductors represents a significant investment by DOD. DESC, which supplies semiconductors common to two or more of the military services, manages over 68,000 different types of semiconductors and semiconductor devices. The cost of procuring those items in 1981 was in excess of $58 million.[10] However, that represents only a fraction of the total military requirement since each military service procures its own semiconductors which are unique to that service. Total defense requirements for semiconductors were estimated to be in excess of $2 billion for 1981. Estimated growth in demand over the next five years is expected to exceed 15 percent annually.[11]

With the increasing use of semiconductors in military systems, our mobilization capability depends on continued supplies of semiconductors and semiconductor devices. It would then seem that the semiconductor industry would be an apt subject for industrial preparedness planning, especially in view of the concern expressed regarding the foreign dependency issue.

Industrial Preparedness Program

By the Defense Production Act of 1950 and the Federal Civil Defense Act of 1950, the DOD is tasked with the responsibility to insure that the United

States has an adequate industrial base.[12] However, action taken to meet this responsibility has been less than adequate. The 1980 Congressional study found that the DOD had at that time neither an on-going program nor an adequate plan to address the industrial base preparedness issue.[13]

The lack of emphasis on industrial preparedness by DOD stemmed from the adoption of the short war scenario for operational planning.[14] A short war is one that would be fought with the equipment on hand, since it assumes that the war would be over before the production base could be activated. Until recently, the guidance issued by the Secretary of Defense contained the assumption that all future wars would be short wars. This guidance removed any priority given to the industrial preparedness program and reduced, if not eliminated, any concern with foreign dependency issues.

Even with increased interest by DOD in industrial preparedness, it is questionable whether the program, as presently structured, could adequately address the military's requirement for semiconductors. The program focuses too narrowly on a limited number of selected items (currently 2000) as subjects for industrial preparedness planning.[15] Given the large number of different items that the DOD procures (Defense Logistics Agancy (DLA)) alone oversees the procurement of almost two million types of items),[16] the 2,000 item limitation seems inadequate. However, even for these selected items, the program is found wanting. Projected mobilization requirements for selected items are not always based on realistic data, and they have sometimes fluctuated widely from year to year. Participation by industry in the program, necessary to determine production capacity, is strictly voluntary.

No monetary compensation is provided by DOD for the time and effort expended. As a result, industries' response to DOD industrial preparedness planning surveys is either non-existent or based on superficial and inadequate analysis. These assertions are borne out by a 1981 General Accounting Office study which found the information collected by the program to be of questionable value.[17]

A recent review of the program as implemented by DLA (which did not adhere to the 2,000 item limitation) is instructive with regards to other shortcomings. Based on inputs by the military services, 200,000 items (including some semiconductors) managed by DLA were reviewed to determine the adequacy of war reserve stocks. Through an initial screening process, some 40,000 items were identified as having war reserve shortfalls. Of these, 13,000 were selected for industrial preparedness planning. However, of the 13,000 items found to have production shortfalls, no corrective actions were ever recommended or taken. That part of the program was not implemented because of workload constraints on the planners.[18]

The entire program is again under review.[19] Besides additional funding and personnel already provided for industrial preparedness planning, other changes are being considered. However currently, there is no capability within the program to (1) determine the quantity and types of semiconductors required by the military; (2) determine what percentage of semiconductors used by the military are in fact manufactured in part or wholly off-shore; and (3) determine with accuracy the capacity of the domestic production facilities to manufacture semiconductors entirely within the United States.

Tracing Foreign Dependency

Interviews with DOD officials have confirmed that there is no DOD system in being that permits the origin of semiconductor manufacture to be determined with certainty. The only requirements in this regard are associated with integrated circuits identified as JAN (Joint Army Navy) parts.* JAN nomenclatured integrated circuits manufactured under military specification MIL-M 38510 are required to be fabricated, assembled, and tested by qualified producers on certified lines entirely within the United States.[20] Because of the extensive testing to meet stricter performance requirements, the JAN nomenclatured semiconductors have a substantially higher cost than similar commercial items. As a result, JAN components represent only a small percentage of the total DOD procurement of semiconductors. The majority of these procurements are made by DESC and represent only 10 percent of their total semiconductor purchases.[21]

Since there is no system presently in existence to accumulate the necessary data in the procurement of semiconductor devices, it is virtually impossible to get a feel for the extent of the foreign dependency problem. An assessment of the electronic industry made by the Industrial College of the Armed Forces in 1982, recommended the offshore assembly of electronic components for further study stating the problem thusly:

*Discrete semiconductor devices manufactured under MIL SPEC-M19500 are also identified as JAN nomenclatured items; however, they may be assembled offshore. The qualified producers only have to demonstrate a capability to manufacture the devices entirely within the United States.

> "The full extent of the offshore assembly is not known by the industry at large. Althougn the companies visited had good statistics on final product assembly, they were not aware of the amount of offshore involvement at the lower tiers of component sources and sub-assembly manufacture. The upper tiers (and product vendors) assume that since the products they purchased are from American suppliers, there is little or no offshore involvement."[22]

After considerable discussion and careful review of the types of components, the assessment indicated the assumption of "no offshore assembly" was in error.[23]

The problem of source identification is compounded in the development of new systems for DOD. The procurement of semiconductors is generally left to the discretion of the prime and sub-contractors who use the devices in their equipment assemblage. Often, the contractors assign unique part numbers to the semiconductors. This practice complicates efforts to determine if there has been any offshore processing associated with the components since the original manufacture is not known.

Even if the original manufacture was known, determination of foreign dependency is difficult. DESC after reviewing the problem in 1976 indicated that:

"In spite of such restrictive regulations as the Armed Services Procurement Regulations and The Buy American Act which call for declaration of foreign source items, we often cannot determine with certainty whether a domestic purchased item is not, in fact, totally or partially foreign produced (and our suppliers are not disposed to tell us).[24]

More recently, the National Security Industries Association, Electronics Industry Association, and the Areospace Industries Association collaborated in 1982 with DOD in a study effort to ascertain the scope of foreign dependence on electronic components by sending a questionnaire to their member companies regarding foreign dependency. Only seven companies responded, and the proposed study effort was cancelled due to this poor response.[25]

A proposal considered by the Joint Logistics Commander ad hoc group for determining the depth of foreign dependence in military systems was to have a private contractor analyze four military systems to determine the amount of foreign dependence for electronic components. The contractor estimate for such a study was $1.4 million. The high cost of the study attests to the perceived difficulty of determining the scope of the problem.[26]

An attempt was made to identify foreign dependencies in the procurement of the Single Channel Ground and Airborne Radio System (SINCGARS).[27] Provisions were included in the contract for the contractor to identify all foreign source items. It is not clear, however, that semiconductors

manufactured in part offshore but purchased from United States firms are considered as foreign source items. Also, the additional cost of obtaining this information is not known.

Determining the Problem

While there is no exact measure of the foreign dependency in semiconductors within DOD, there are indications that the potential for this dependency is high. Although JAN nomenclatured integrated circuits are required to be manufactured entirely within the United States, that requirement may not be met in all cases. At a 1982 Mobilization Conference held at the National Defense University, statements were made by a weapons industry representative that even some JAN semiconductors manufactured under MIL-M38510 had some overseas processing.[28]

An analysis of the 616A MODEM, a piece of electronic equipment used by the Air Force in a strategic command, control, and communications system, revealed that over 53 percent of all semiconductors used within the MODEM had a high potential for foreign supplier involvement. If just diodes and transistors are considered, then the potential for foreign supplier involvement is in excess of 85 percent.[29] The total potential is high because (1) there is no requirement by DOD for these semiconductors to be manufactured exclusively in the United States and (2) there is a cost savings which accrues to United States semiconductor firms having offshore facilities to use those facilities when possible. It is believed the 616A MODEM data is typical of other defense systems which use semiconductors.

This belief is borne out by other sources. A senior executive from the electronics industry pointed out that an analysis of four different tactical electronic systems to determine foreign dependency (assembly and testing of semiconductors) found that offshore dependency ranged from 17 to 33 percent.[30]

FOOTNOTES

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CHAPTER III

FINDINGS AND RECOMMENDATIONS

Findings

1. The United States semiconductor industry is an international industry with sizeable offshore manufacturing capacity. Design and fabrication of integrated circuits are primarily done in the United States. However, most assembly operations are done offshore.

2. Third World countries are developing an expertise in semiconductor technology as a result of U.S. firms' foreign based operations. The United States can expect competition from these countries as they develop their own industry and seek to develop regional and even worldwide markets.

3. The United States semiconductor firms technological preeminance and market domination has been targeted by the Japanese. The recent success of the Japanese in taking a large portion of the market for mass memory devices threatens the continued existence of the United States semiconductor industry.

4. Semiconductor components and devices are incorporated in most of our military hardware and are critical to their successful operation. The use of semiconductors by the military is projected to increase at a rate of 15 percent per year over the next five years.

5. Numerous studies have recognized a potential problem in the dependency of the military for semiconductors made by an industry that has a significant part of its assembly capacity located offshore. The extent to which the military uses semiconductors that have in fact been produced in part offshore

has never been documented. The specific semiconductors which are critical and must be produced within the United States are not completely known.

6. The industrial preparedness program of DOD has been ineffective in addressing most industrial preparedness requirements including those involving foreign dependency issues. The program as currently structured and implemented is not expected to identify or correct any domestic semiconductor production shortfalls.

7. There is no information system within DOD that permits the origin of semiconductor manufacture to be determined with certainty. Information and data gathered as a result of this study only confirm that most semiconductors used by the military have a high potential for being manufactured in part offshore.

Recommendations

The primary issue being faced today relative to the military's use of semiconductors is the survivability of the United States semiconductor industry. It makes little sense to be concerned overly about a foreign dependency resulting from United States firms having some portion of their manufacturing operations offshore, when the military could become dependent on foreign firms having their entire manufacturing process offshore. The DOD and other governmental agencies need to be concerned about the Japanese targeting of the United States semiconductor industry in Japan's efforts to dominate, if not take over, the market. To protect the defense industrial base, the DOD needs to initiate and support efforts to strengthen the United States semiconductor industry's capability to respond successfully to the Japanese challenge.

The secondary issue is the question as to whether or not offshore assembly operation for semiconductors are in general detrimental to the defense interests of the United States. Assembly plants, while located primarily in Asia, are in fact found throughout the world including Europe, South America, Central America, and in the Caribbean area. Such a wide dispersal certainly reduces vulnerability to enemy action in time of war. Additionally, since the product is of such small size, the logistical problems of transportation are considerably reduced. A considerable supply of semiconductors can be easily transported on one large aircraft. However, for specific critical semiconductors, offshore dependence of any sort may be unacceptable. Given these factors, the DOD needs to determine in the abstract (1) whether or not foreign dependency poses a threat to national security, and (2) whether or not geographically dispersed sources satisfy national interest. Moreover, the DOD needs to identify those items which must be produced domestically and to provide a mechanisms for their production. The establishment of a Defense Electronic Components Production Center under DLA could well satisfy this latter requirement.

The Tertiary issue: If the answer to the above is in the affirmative, then a information system needs to be developed by which the military can assess the degree of dependence to determine appropriate corrective actions. A necessary first step would be to accumulate complete procurement data on type and number of semiconductors purchased to include identification of any foreign processing in their manufacture (including assembly and testing). Recognizing that this might be an expensive process, it could be most easily

and selectively accomplished by establishing a procedure whereby major contractors provide this information as part of the contractual data requirements such as used in SINCGARS. The other side of the foreign dependency equation is to determine for critical items, (1) the existing ability of United States firms to manufacture semiconductors entirely within the United States, and (2) those specific semiconductors that should be produced and stockpiled by the proposed Defense Electronics Components Production Center.

APPENDIX A

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APPENDIX B

GLOSSARY

Bit. A unit of information consisting of a binary digit that can have one of two values-e.g., "0" or "1," "+" or "-." Digital circuits operate by manipulating bits which are represented by voltage levels.

Chip. A small piece of a semiconductor material such as silicon on which an integrated circuit has been fabricated.

Ditgital. Refers to electronic circuits or devices, the inputs and outputs of which are norminally discrete voltage levels. Analog or linear circuits, in contrast, have imputs and outputs that vary continuously over a range of voltages. Virtually all computers process information in digital form.

IC. Integrated circuit. An electronic circuit made by fabricating components such as resistors, capacitors, and transistors on a single piece of a semiconductor material, usually silicon.

Lithography. Processes similar to printing used in fabricating integrated circuits. Lithography is used to expose chemical resists as part of the process of laying out circuit patterns. Light X-rays, or electron beams can be used. All present commercial processes use light. The resists are analogous to the light-sensitive emulsions of photographic film.

Microcomputer. A computer based on a microprocessor and using other integrated circuits for support functions, or, alternatively, containing all functions on one chip (single chip microcomputer).

Microprocessor. An integrated circuit that can serve as the processing unit for a digital computer. Also used to provide particular digital logic functions as an alternative to custom-designed integrated circuits. Microprocessors vary in their word lengths--the number of bits in the words they manipulate--hence, 4-bit, 8-bit, etc.

Minicomputer. A computer that typically costs under $100,000 and does not need specially trained operators or special facilities.

MITI--Ministry of International Trade and Industry, Japan.

MOS--Metal Oxide Semiconductor. Refers to both transistors and integrated circuits. MOS ICs are unipolar as opposed to bipolar; they are denser and dissipate less power than bipolar ICs, but are usually slower. The most widely used RAM's and microprocessors are MOS devices.

Offshore manufacture. The production of parts and components, and/or their assembly, in plants located in foreign countries, followed by shipment back to the home market or to third country markets.

RAM--Random Access Memory. An integrated circuit which functions as read/write memory for a digital processor. Each memory location can be addressed directly (random access) and its contents read and/or changed (written).

Semiconductor. Electronic devices such as transistors or integrated circuits based on silicon or other materials that have electrical conductivities intermediate between insulators such as glass and conductors such as metals (the term semiconductor also refers to the materials--e.g., silicon--themselves).

SIA. Semiconductor Industry Association.

Transistor. An active semiconductor device that can function, for example, as an amplifier. Transistors have replaced vacuum tubes in many applications.

VHSIC--Very High-Speed Integrated Circuit. Name given to a U.S. Department of Defense R&D program aimed at military needs for very large-scale integrated circuits. The designation refers to the high speed required for applications such as signal processing.

VLSI--Very Large-Scale Integration. Refers to integrated circuits with of the order of 100,000 circuit elements.

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